Dear Mr. Fox:

Thank you for your Letter of November 5, 2002 providing comments on the Preliminary Draft Columbia/Snake Rivers Mainstem Temperature Total Maximum Daily Loads (TMDL). Attachment one to this letter provides responses to your November 5, 2003 comments. Attachment 2 provides responses to the July 2002, review of EPA's Water Quality Model used for development of the TMDL that was developed for Bonneville Power Administration by MWH and GEI Consultants, Inc.

We addressed all of your comments from November 5, 2000 in detail in Attachment 1 but I would like to highlight a few of them. First, your letter refers to the TMDL target temperatures as extremely low. The temperature targets in the TMDL are not low. In fact, they are considerably higher than water quality standards normally are for the protection of salmon. For example, Oregon's criterion for the protection of salmon rearing is 64 °F (17.8 °C) and for salmon spawning is 55 °F (12.8 °C). The targets in the TMDL are far higher than these criteria because they are tied to natural conditions. Our model simulations that estimate conditions in the absence of human activity in the main stems of the river indicate that temperatures would be considerably higher than these criteria.

Your letter states that EPA unreasonably assigned almost the entire burden of attaining the temperature standard at Columbia River Mile 4 to the fifteen mainstem dams. Actually, EPA only assigned the burden of correcting the temperature impacts caused by the dams to the dams. We modeled the temperature effects from the main stems' in-stream causes of temperature impairment. The resulting temperature impairment is the result of the those instream causes: dams and point sources. Dams are given the burden of rectifying the impairment caused by the dams.

Your letter expressed concern that EPA ignored the Federal Advisory Committee's recommendation that large existing dams be given a background allocation in the TMDL because they are impossible or virtually impossible to remove. Actually, the approach used to develop the TMDL is very consistent with the FACA Committee's seven recommendations that pertain to this situation. The gist of the FACA report is that ultimately the existence of dams (not the operation, maintenance or potential modifications) should be given a background allocation. But first some steps have to be taken to accomplish that. The committee's recommendations lay out a process that focuses in on the temperature improvements that are technically and economically feasible at the. Before going through this process, there is no way to know how much of the impairment due to dams to allocate to their existence as opposed to their operation, maintenance or modification. The process begun by the TMDL is nearly identical to that recommended by the committee.

The MWH model review provided technical comments on the model, most notably that one dimensional modeling has its limitations and that the data available for modeling temperature in the Columbia and Snake Rivers are less than what we would like. But the MWH review greatly misconstrued the intent and importance of the assessment in the modeling report that compared the relative impacts to temperature from dams and tributaries. That assessment was a screening analysis intended to help us with problem formulation for the TMDL. It has been followed by two years of technical work, guided by an interagency technical committee resulting in two important documents, the

draft TMDL Problem Assessment and the preliminary draft TMDL. The MWH review apparently construed this assessment to be the conclusive analysis for the TMDL. This led to absurd conclusions, such as three degree improvements in temperature would be ignored by EPA and that EPA implies that temperature improvement of tributaries should be abandoned. Let me assure you that no improvement in temperature in the main stems will be ignored by EPA. Further, EPA is deeply involved in the development of tributary TMDLs. Our role is primarily approval/disapproval and support for the states. We processed over ___ TMDLs in FY 2002, many of them for tributaries to the Columbia/Snake river system. In the future, we would welcome the opportunity to meet with and work with your technical reviewers during their review process so that misconceptions can be avoided and the review kept on point.

The MWH review points out the limitations of a one dimensional model and the shortcomings of the existing data set for modeling temperatures in the Columbia/Snake Rivers. The limitation of a one dimensional model is, of course that it is one dimensional, but the advantage of a one dimensional model is that it is more likely to yield acceptably accurate results in the face of sparse and variable input data. The preliminary draft TMDL describes how we use the average temperature results of the model to establish the TMDL. The use of average model results for TMDLs for instantaneous water quality standards is commonplace. The states and tribes that promulgated the standards are on our technical and steering committees for the TMDL and concurred in the modeling approach used.

As for the data, while it is sparse across the breadth of the whole basin, it is rich in terms of continuity. We were able to develop 30 year long data sets for meteorology and hydrology. This is important in light of the tremendous natural variation in these parameters. As a result of these 30 year data bases, the TMDL is able to account for the natural variation. This is very important in this TMDL because the water quality standards actually vary with natural temperature. If we had delayed the TMDL a year or 2 years to collect more data representative of the entire basin, we perhaps could model those specific years more accurately but we would not capture the long term natural variation which is essential in this TMDL.

It is important to note that, while the MWH report details the limitations of the model approach and the data, it does not evaluate the results of the model. It does not compare the results to observed data. Such an evaluation shows that the model simulations compare quite well with observations and compare favorably with the results of other temperature modeling efforts used to develop TMDLs. Never-the-less, we do continue to fine tune the model and upgrade the input data sets as data becomes available to us. We recently improved in-channel geometry based on data supplied by the Corps of Engineers and we are evaluating meteorological data that the Pacific Northwest National Laboratory informed us about.

Your letter expressed concern that EPA ignored the Federal Advisory Committee's recommendation that large existing dams be given a background allocation in the TMDL because they are impossible or virtually impossible to remove. Actually, the approach used to develop the TMDL is very consistent with the FACA Committee's seven recommendations that pertain to this situation. The gist of the FACA report is that ultimately the existence of dams (not the operation, maintenance or

potential modifications) should be given a background allocation. But first some steps have to be taken to accomplish that. The committee's recommendations lay out a process that focuses in on the temperature improvements that are technically and economically feasible at the. Before going through this process, there is no way to know how much of the impairment due to dams to allocate to their existence as opposed to their operation, maintenance or modification. The process begun by the TMDL is nearly identical to that recommended by the committee.

Attachment 1
Response to Bonneville Power Administration Letter of November 5, 2002
Comments on the Preliminary Draft Columbia/Snake Rivers Temperature TMDL

1. "EPA fails to consider all of the Columbia and Snake Rivers' uses and values despite the Clean Water Act's requirement to do so."

Response: The states develop water quality standards that will protect all designated uses of the river. Generally, achieving water quality that will protect the most sensitive use, in this case salmon, will protect the other uses. In this way, water quality standards consider all the uses as required by the CWA. The real issue here is the concern that the only measure that will achieve the water quality standards that are intended to protect salmon uses is the removal of dams. The TMDL does not call for dam removal. The implementation plan will determine if there are feasible measures to meet the water quality standards with the dams in place. If not, the water quality standards and the TMDL can be amended, at the discretion of the states, with EPA approval, to reflect the level of water quality that can be achieved when feasible measures to improve temperature are implemented.

Your comment refers to the TMDL target temperatures as "extremely low" (page 2, second full paragraph). The temperature targets in the TMDL are not low. In fact, they are considerably higher than water quality standards normally are for the protection of salmon. For example, Oregon's criterion for the protection of salmon rearing is 64 °F (17.8 °C) and for salmon spawning is 55 °F (12.8 °C). The targets in the TMDL are far higher than these criteria because they are tied to natural conditions. Our model simulations that estimate conditions in the absence of human activity in the main stems of the river indicate that temperatures would be considerably higher than these criteria.

2. "EPA's chosen methodology actually *precludes* the statutorily mandated consideration of uses and values like recreation, agriculture, industry, and navigation, because it simulates the mainstem temperature conditions in the absence of human activities in the mainstems."

Response: This comment refers to our modeling of the river in the absence of human activity in order to determine the temperature targets for the TMDL. The concern is that "EPA seeks to establish a regime under which the dam operators must achieve standards that are incompatible with their fundamental operational requirements." It is not EPA's intention to establish a regime that is incompatible with fundamental operational requirements. In order to determine if dams can be operated to achieve the water quality standards, we have to first establish what the standards are. Modeling the river with the dams removed was chosen as a method for determining what the temperature would be in the absence of human activity as required by the water quality standards. In fact it was the only method that would estimate temperature in the absence of human activity. The implementation plan will determine if there are feasible measures to meet the water quality standards with the dams in place. If not, EPA's water quality standards regulations allow modification of the water quality standards due to the effect of dams. Modeling the river with the dams out in no way implies that the TMDL is saying the dams have to be removed, and we will consider any proposed language from BPA to make that point in the TMDL.

3. "EPA unreasonably assigns almost the entire burden of attaining the temperature standard at

Columbia River Mile 4 to the fifteen mainstem dams, despite the fact that sources outside the TMDL boundary contribute heat to the river system."

Response: EPA only assigned the burden of correcting the temperature impacts caused by the dams to the dams. We modeled the temperature effects from the main stems' in-stream causes of temperature impairment. If we add the tributaries and sources of the basin upstream of the TMDL in Canada and Idaho, perhaps the temperature targets will be lowered. The added impairment will then be attributed to the tributary and upstream causes. The impairment due to dams will remain the same and be attributed to dams.

4. "EPA ignores, without providing justification, the Federal Advisory Committee's recommendation that large existing dams be given a background allocation in the TMDL because they are impossible or virtually impossible to remove."

Response: The approach used in developing the TMDL does not conflict with the FACA recommendations. All seven FACA recommendations related to dams have to be taken in context. The gist of the FACA report is that ultimately the existence of dams (not the operation, maintenance or potential modifications) should be given a background allocation. But first some steps have to be taken to accomplish that. The TMDL should be developed on the assumption that a feasible TMDL can be developed for impairments involving dams. The TMDL should include allocation for dams. Changes to operation, maintenance and potential modifications should be included in the implementation plans to meet the allocations. As a last resort, if no strategy can be found to address impairment due to the dam, states may amend the water quality standards. At this point the states will know what background allocation to assign to dams. They will have determined what the feasible improvements in temperature are that will result from changes in operation, maintenance and potential modifications.

In this way the process focuses in on the temperature improvements that are technically and economically feasible. Before going through this process, there is no way to know how much of the impairment due to dams to allocate to their existence as opposed to their operation, maintenance or modification.

5. "EPA fails to address questions about scientific integrity and sufficiency of data underlying the TMDLs assumptions an conclusions."

Response: The concern here is apparently that EPA has not yet responded to a BPA funded review of the EPA model conducted by Montgomery, Watson, and Harza/GEI. The comment states that EPA did not respond because of "expressed time constraints". We did not respond because the report was never transmitted to us with a request for comment or response. We have still never received the report under cover letter from BPA with a request that it be considered in the development of the TMDL or that we respond to it. Never-the-less, a detailed response is included here as attachment 2 to our cover letter.

The MWH report represents BPA's second contract to review the thermal energy budget

model used by EPA Region 10. The first BPA-funded report, entitled "A Review of EPA Region 10 Columbia River Temperature Assessment Simulation Methods" dated September 1999 covered the same material as the present report. The first BPA-funded review was one of several peer reviews of EPA's temperature model. EPA responded to all reviews, including the first BPA-funded review, as required by EPA's peer review policy. All responses were made part of the public record.

We were unaware that there are questions of scientific integrity concerning our work on the TMDL. EPA holds itself to the highest levels of scientific integrity in conducting research or applying science to problem solving or regulatory program. EPA Administrator Carol Browning issued a Peer Review Policy in 1994 to ensure that EPA policy decisions rest on sound, credible science and data. EPA's Peer Review Program was subsequently instituted by the EPA Science Policy Council. The EPA model used for the Columbia/Snake River TMDL was peer reviewed in accordance with this policy. Mr. David Wagner, Ecosystem Management International, Inc. and Professor Scott Wells, Portland State University did the formal review. In addition, we accepted comments as part of the review process from the following parties:

Harza Engineering Company under contract to the Bonneville Power Administration;
Dr. Peter Shanahan of HydroAnalysis, Inc. under contract to Potlatch, Corporation;
Professor M. Bruce Beck under contract to Potlatch Corporation;
U.S. Army Corps of Engineers, Water Management Division, Portland Division;
Mr. Stuart McKenzie, USGS, Retired

Many modifications to the model report were incorporated as a result of these comments. All of the comments and EPA's responses to them were published as Appendix E of the final report. In addition to the peer review process, EPA has developed the TMDL in a very open process. Nine public workshops were held to receive input on each specific step in the TMDL process: Water Quality Modeling; the Problem Assessment; Loading Capacity and Allocations and the Preliminary Draft TMDL. We received many excellent comments and new information through this public involvement process and made many changes to the TMDL as a result. We scheduled follow up meetings with a number of the commentors to better understand their recommendations and we incorporated new information into the TMDL that we received from commentors. That includes new information that effected the temperature model. We have conducted a very open and inclusive process and we are confident that any questioning of scientific integrity is unfounded. We certainly understand that there are scientific disagreements.

Regarding sufficiency of data, one of the purposes of modeling is to gain understanding of the functioning of a system when data is insufficient to provide that understanding. While data is sparse across the breadth of the whole basin, it is rich in terms of continuity. We were able to develop 30

year long data sets for meteorology and hydrology. This is important in light of the tremendous natural variation in these parameters. As a result of these 30 year data bases, the TMDL is able to account for the natural variation. This is very important in this TMDL because the water quality standards actually vary with natural temperature. If we had delayed the TMDL a year or 2 years to collect more data representative of the entire basin, we surely could model those specific years more accurately but we would not capture the long term natural variation which is essential in this TMDL.

6. EPA's methods will result in a TMDL that will encourage protracted litigation.

While we cannot prevent people from suing the federal government, we can provide the government with a strong basis from which to defend itself. By following the letter of the law and regulations we are providing that strong basis. In response to this comment, we have added a great deal of language (already provided to BPA during our meeting in Portland on December 17, 2002) to clarify the role of the TMDL in the entire water quality improvement process laid out in the Clean water Act, to address the possibility of amending water quality standards if they cannot be attained and to explain the efforts that the FCRPA agencies have already made to improve temperature.

Attachment 2:
EPA response to "Review of a 1-D Heat Budget Model of the Columbia River System"
by MWH and GEI Consultants, Inc.
for Bonneville Power Administration

General

Bonneville Power Administration (BPA) contracted MWH and GEI Consultants, Inc. (together identified as MWH hereafter) to review EPA's March 2001 report regarding the development of a Columbia River temperature model. The report, dated July 2002, is titled "Review of a 1-D Heat Budget Model of the Columbia River System". The MWH report represents BPA's second contract to review the thermal energy budget model used by EPA Region 10. The first BPA-funded report, entitled "A Review of EPA Region 10 Columbia River Temperature Assessment Simulation Methods" dated September 1999 covered the same material as the present report. The first BPA-funded review was one of several peer reviews of EPA"s temperature model. EPA responded to all reviews, including the first BPA-funded review, as required by EPA's peer review policy. All responses were made part of the public record. More importantly, these reviews (including the first BPA-funded review) provided constructive criticisms that have resulted in what EPA believes to be improvements in the temperature model as used in the Columbia River temperature TMDL

EPA has completed additional work since March 2001 related to the Columbia/Snake River mainstem temperature TMDL Two documents of particular importance for this project are the Draft Problem Assessment and Preliminary Draft TMDL (see EPA Region 10 website). Several topics raised by MWH are addressed in more depth in these recent documents. Further, the role of the model and the modeling report within the context of the TMDL is made more clear when the three documents are considered together.

The MWH report appears to misconstrue the role of the model and the role of the modeling report within the context of the TMDL. For example, the MWH report states

> "The *EPA violation criterion creates an artifact that both exaggerates the thermal problem and minimizes credit to mitigate for it in incremental steps. By selecting days of violation above 20 °C, EPA counts 0.1 °C excursion above 20 °C as serious as a 3 °C*

violation. Likewise any mitigation that reduces the temperature from 23 °C to 20.1 °C is assessed as zero benefit to salmon and a violation of code."

This statement is completely untrue. The preliminary draft TMDL and the Problem Assessment are the documents that evaluate exceedances of water quality standards; not the model report. Those documents are very clear that the TMDL is being established to achieve state and tribal water quality standards. The TMDL is not written in terms of days exceeding 20 °C, but in terms of a quantitative, parametric assessment of temperature and the loads that will achieve compliance with water quality standards.

The qualitative approach used in the 2001 report was a screening tool to compare the relative temperature effects of tributaries and dams:

"The objective of this study is to determine for a given sequence of hydrology and meteorological conditions, the relative impacts of the operation of dams and reservoirs on the thermal energy budget of the main stem Columbia and Snake rivers compared to the thermal input from surface and groundwater inflows."

Estimation of the frequency of excursion above the benchmark of 20 °C was a means of summarizing the vast array of quantitative results in order to characterize and compare the impacts of dams and tributaries. It had no regulatory significance. The report states quite clearly that the benchmark of 20 °C was chosen because adult salmon are at risk when temperature is warmer. The report states that *"although the benchmark does represent certain aspects of the physiological requirements of salmonids this report does not view it as a surrogate for water quality criteria [MWH's violation criteria] or as part of an ecological risk analysis."*

This misunderstanding of the use of the benchmark assessment is a serious shortcoming of the MWH report that effects assessments throughout the report. Another important example is on page 42 where the report states *"If these rivers [Yakima, Umatilla and John Day] were thermally improved, they would reduce the magnitude of thermal loading to the mainstem, something the EPA model is insensitive to. That is because, if cooler tributaries were to lower the mainstem from 22 to 20.1 °C, the model would report the same magnitude of "violation".* This is completely incorrect. The model outputs are temperatures and the tributary temperatures are inputs to the model. If those tributary temperatures were reduced the model outputs would be correspondingly improved mainstem temperatures.

Another serious shortcoming of the MWH report is its failure to discuss the degree to which the RBM10 model estimates correspond to observed mainstem temperatures, which is the first benchmark for evaluating the performance of a water quality model. A reader of the first 45 pages of highly critical MWH comments might conclude that the RBM10 model cannot possibly provide reasonable estimates of temperature in the Columbia and Snake Rivers. It is not until MWH is describing the application of a different one-dimensional heat budget model, MASS1, that it briefly notes that both models show general agreement between simulations and observations (Pg. 47).

In fact, the model simulations agree well with observations, especially observations from recent years which have been collected more consistently and with an effort toward quality assurance/quality control. For example the mean difference between model simulations used for the TMDL and observations for 1995 through 1999 ranged from -0.20 °C with a 90% confidence interval of ± 0.4 °C at Bonneville Dam to -.24 °C with a 90% confidence interval of ± 1.4 °C at Ice Harbor Dam. The statistics for the absolutes differences at each site are, for Bonneville, an absolute mean difference of 0.26 °C ± 0.28 °C, and for Ice Harbor, an absolute mean difference of 0.75 °C ± 0.79 °C.

Water Quality Standards

MWH states that the EPA model focuses on the number of exceedances of the "existing standard of 20 °C". The existing standard is not 20 °C and the TMDL does not focus on 20 °C or the number of days that 20 °C is exceeded. The 2001 model report did evaluate the number of exceedances of a 20 °C benchmark, but the report is not an evaluation of water quality standards violations. Furthermore, the report makes it clear that the use of the 20 °C benchmark is not meant to be viewed as "a surrogate for water quality criteria or as part of an ecological risk analsysis".While 20 °C is one of the numeric criteria applicable to a portion of the Columbia River, the water quality standards for Oregon and Washington include narrative requirements along with numeric criteria. EPA has evaluated the standards in subsequent documents in support of the TMDL (see EPA TMDL website).

The MWH report has a paragraph 1.4 entitled "Thermal Criteria of the EPA Model". The model incorporates no thermal criteria. It is a quantitative tool for estimating water temperature when given starting temperatures, meteorological data and river flow and geometry. The model does not calculate exceedances of any criteria or number of days over criteria or anything like that. The model calculates water temperatures at specific places at specific times. Those temperatures can then be used outside of the framework of the model to evaluate temperature conditions of the river. One way to do that is to compare the simulated temperatures to water quality standards. The modeling report did not do that, though the subsequent preliminary draft TMDL does that at great length. The modeling report did go on to estimate the number of days that the water temperature exceeds a 20 °C benchmark under various scenarios (impounded river, free flowing river, cold tributaries) as an analytical tool for understanding how the thermal regime of the river is modified under these scenarios. As the report states, the benchmark assessment "has been treated in this report as part of the problem formulation for watershed planning under Section 303(d) of the Clean Water Act." The contribution of this assessment to the problem formation is that structural changes to the rivers associated with the construction and operation of the dams play an important role in changing the temperature regimes of the rivers, while the contributions of the tributaries is smaller. The subsequent problem assessment and preliminary draft TMDL continued the investigation of the relative impacts of the various sources of heat to the river.

Upstream Water Temperature

MWH asserts that EPA does not acknowledge that "upstream water is often the strongest predictor of downstream temperature." EPA's report is quite clear in defining the model boundaries and assumed inputs, and the assessment is explicitly focused on the effects of those mainstem dams below the model boundaries on river temperature. Model simulations of the "impounded" and "unimpounded" conditions use the same upstream boundary temperatures; therefore, differences in temperatures for the two cases incorporate the effect of upstream temperatures. The report discusses the factors that govern changes in temperature between initial conditions (upstream) and some downstream point. The main factors are meteorology (wind speed, air temperature, cloud cover, air moisture content), river depth, and travel time between the two points. Meteorology determines the maximum temperature the water body can achieve; the depth and certain components of meteorology determine the rate at which the water body exchanges heat with the atmosphere; and travel time determines the importance of initial conditions (upstream temperature). Contrary to the MWH report assertion that EPA does not acknowledge the importance of upstream conditions, this assessment was done because EPA understands that importance and was testing the hypothesis that the structural changes to the rivers were sufficient to modify travel time (and thereby, the importance of upstream conditions) to the extent that the temperature regimes of the rivers were modified. The result of the assessment was that upstream conditions play a more important role in determining downstream temperatures in the free flowing river than in the impounded river because of the changes to travel time. That is, the changes to the rivers have decreased travel time and therefore, have increased the relative importance of initial conditions in determining downstream temperature.

Data Quality

MWH finds that EPA's data is inadequate, noting the EPA admits that data quality varies considerably across the basin. First, it should be noted that none of the data used in the model development was collected by EPA. Rather, the EPA analysis rests on information collected by numerous agencies including the U.S. Army Corps of Engineers, Bureau of Reclamation, National Weather Service, U.S. Geological Survey, and the state environmental agencies. EPA does not have the responsibility or the resources to collect the vast quantity of data used in this model. Furthermore, it should be noted that EPA Region 10, as an active participant in the Water Quality Team and the RPA 143 sub-group, has been an advocate of improved quality control measures for data collection on the Columbia. We believe that this advocacy has played a major role in (1) recognition of the shortcomings of some data collection methods and (2) improvements in quality control procedures used to measure and report environmental data for the Columbia River.

While analysts should strive to identify and reduce measurement and model error to the extent possible, error and uncertainty are a fact of life. EPA strongly disagrees with the implicit suggestion in MWH's criticisms that the data quality problems are so great that no analysis should be undertaken. Most environmental assessment work, including water quality model development, requires the use of information collected in the past. In a system the size of the Columbia basin, with no data collection strategy for temperature state estimation, the variability in data quality is to be expected. EPA has identified issues in data collection and minimized the variance in modeled and measured temperatures for a 30-year record. MWH does not offer concrete suggestions for improving model performance.

Effects of Reservoirs on Temperature

MWH states that EPA has assumed that all reservoirs are likely to affect temperature similarly, and that MWH analysis shows that the variety of depths, lengths, widths, and gradients of the reservoirs would each produce different surface-to-volume ratios and thermal behavior if removed. EPA's model explicitly accounts for the varying geometry of the river and impoundments, so it is inaccurate to portray EPA's analysis as assuming that all reservoirs affect temperature similarly.

1-D Model

MWH asserts that the assessment of "homogenous" or cross-sectional average temperatures, the "measurement bias" of the model, and the assessment of exceedance only (not magnitude of the exceedance) make the assessment results a poor indicator of impacts to salmon. EPA believes that RBM10 provides reasonable, one-dimensional temperature estimates at the basinwide scale, and the model has provided valuable information about the effects of river management on temperature. At the same time, two-dimensional analysis may provide additional insights into temperature regimes within the more stratified reservoirs. For this reason, EPA continues to evaluate two of these reservoirs (Lower Granite and Grand Coulee) using the CE-QUAL-W2 model. EPA believes both one- and two-dimensional analysis is relevant to salmon health.

Effect of Tributaries

MWH uses a simple hypothetical example to suggest that EPA's use of a fixed benchmark (20 °C) for evaluation conceals the true effects of tributaries, and that EPA "implies that we should abandon improving thermal TMDL's in our tributaries, a conclusion most would be surprised as coming from EPA." Tributary impacts were explicitly evaluated over a long term simulation. Given the voluminous estimates provided by the model (daily values for a 30 year period), including estimates of temperatures near the benchmark value, it is reasonable to expect the number of exceedances of the benchmark to change significantly if the tributary effect was significant. EPA estimated the change to be minor and appropriately reported this finding. Nowhere in the EPA report is there a suggestion that projects to improve tributary temperatures should be abandoned.

The MWH report states that "This model [the EPA model] implies that we should abandon improving thermal TMDL's in our tributaries, a conclusion most would be surprised as coming from EPA." It is not clear what is meant by this statement, but if the contention was that EPA is implying that TMDLs should not be developed for tributaries and tributary water temperature should not be improved where it is impaired, that contention is absurd. The MWH report construes a simple analytical procedure conducted to compare the relative importance of dams and tributaries to be the entire analytical basis for the TMDL. The preliminary draft TMDL does focus on the mainstem because TMDLs are planned, scheduled and in many cases underway or completed for the tributaries. To the extent that these TMDLs call for cooler temperatures in the tributaries, they could ultimately benefit mainstem temperatures as they are implemented. But these tributary TMDLs will not address

dams and point sources on the main stems. The mainstem TMDL fills that gap. Before embarking on the ambitious task of a 900 mile, multi-state TMDL, we needed to verify that the instream sources of temperature perturbation are indeed sufficient to warrant the main stem TMDL. The subsequent design and development of the main stem TMDL was based around the instream sources.

Steady vs Unsteady Flow

MWH makes brief reference to EPA's use of gradually-varied flow methods when the river "is actually an unsteady flow". MWH fails to provide any additional information indicating that use of unsteady flow hydraulics improves heat budget model performance for this river system. Given the consistent performance of RBM10 under a variety of conditions, including highly variable flow augmentation periods on the Snake River as well as more recent tests on the unregulated Fraser River in British Columbia, EPA believes that the cost of adding the complexity of unsteady flow hydraulics to model set-up and operation outweighs the limited benefit (if any) to simulation results. The same can be said for MWH's concerns that the model does not include longitudinal dispersion. Given limited assessment resources, EPA's goal is to develop models that are as simple as possible yet captures the predominant drivers of system variability at the length and time scales of interest.

Meteorological Data Substitution

MWH states that it found that some of the wind speed and vapor pressure data are duplicated between stations, implying a mistake in the construction of input files. MWH fails to note that this duplication was an intentional step taken to improve meteorological data coverage, and EPA documented the assumption that these two parameters were regional phenomena in the report (Pg. 35 of EPA report).

MWH then states that the duplicated data must be carefully screened to remove the estimated 5% of cases where MWH discerned physically impossible conditions in the dataset. EPA believes that editing the data sets to eliminate a small number of physically impossible data pairs will not remove the uncertainty in the data nor necessarily improve model performance. EPA notes that overall model performance is reasonable despite the input data uncertainties, including uncertainties in the meteorological dataset.

Evaporation Assumptions

MWH states that EPA's assumption that the evaporation rate is equal in both existing and free-flowing river scenarios is flawed. EPA believes that this is a reasonable assumption but recognizes the uncertainty of this assumption. A plausible alternative would be to assume that evaporation is

greater in the free-flowing river due to higher velocities and turbulence (how much greater is guesswork). This would result in cooler simulated temperatures for the free-flowing river.

MWH states that the application of a 1-D model to stratified impoundments over-estimates the evaporation rate and therefore exaggerates the difference between free-flowing and impounded river temperatures. They note that a stratified impoundment has a higher evaporation rate than it would if it were completely mixed, as assumed in one-dimensional analysis, since the surface temperature for the mixed river would be lower. MWH then states "If this condition is not accounted for...the resulting deduced cooling rates would tend to be over estimated". This is correct, because the greater cooling of the heated surface layer would be reflected in lower tailrace temperatures than would be calculated by the 1-D model. This would necessitate an increase in the 1-D evaporation rate to match tailrace temperatures. MWH then goes on to assert that this 1-D evaporation rate exaggerates the effect of impoundments on the free-flowing river. MWH fails to note that the degree of over-prediction is directly tied to the degree of stratification of the waterbody. In this system, the differences between surface temperatures and cross-sectional average temperatures are generally minor due to the run-of-river configuration of the dams.

MWH continues with the assertion that the estimated evaporation rate "would yield a conclusion that the river cooling rates were disproportionately high and that the original reservoir cooling rates were disproportionally low. Such bias would of course exaggerate the beneficial attributes of a natural river (no reservoirs) and underestimate the cooling potential of a reservoir". First, the estimated evaporation rate does not bias the simulations of the impounded condition at all, because the rate is estimated using measured temperatures. Second, EPA believes any difference in the evaporation rate would be minor in these minimally stratified impoundments. Finally, evaporation in all likelihood would be somewhat higher in riverine than impounded conditions.

MWH concludes with a suggestion to express evaporation rates as functions of instantaneous water temperatures, air temperatures, barometric pressures, wind speeds, and humidity. RBM10 calculates net evaporation based on these variables and the evaporation rate (which is an empirical constant) at each time step. MWH suggests a variable rate but provides no suggested approaches or literature sources to accomplish this task. EPA welcomes additional research in this area, but in its absence, reiterates that the model provides reasonable estimates with a constant or seasonal rate.

RBM10 and MASS1

MWH includes a chapter entitled "Review of Alternate Models that Might be Applied to the Issue" and then proceeds to describe only one alternate model, Batelle's MASS1 model. This review is breathtakingly short (3 pages) and provides scant details about the similarities and differences between RBM10 and MASS1.

Since both are one-dimensional heat budget models with similar boundaries and available data, EPA would expect similar results from the two models. This appears to be the case as MWH states

that both models predict temperatures to within 1.0 - 1.5 °C of measured temperatures, and both models predict a temporal shift in spring heating and fall cooling due to the impoundment of the river by hydroelectric dams.